CLAIMS

1. A bipolar band-to-band infrared photodetector-diode, or laser diode, or light-emitting diode, or amplifier, or electrooptic modulator-diode comprising

    (a) a silicon substrate,

    (b) a strain-relaxed $Ge_{1-y}Sn_y$ or $Ge_{1-y-z}Sn_ySi_z$ buffer layer upon Si, known as a virtual substrate, VS

    (c) an active direct-bandgap region made up of a single-quantum-well heterostructure or a multi-quantum-well stack,

    (d) a strain-relieved capping layer of $Ge_{1-y}Sn_y$ or $Ge_{1-y-z}Sn_ySi_z$ matching the VS composition,

    (e) metallic electrical contacts to the Si substrate and/or capping layer.

2. The devices of claim 1 wherein the substrate is doped N-type or P-type while the capping layer is doped P-type or N-type to form an NIP or PIN diode,

3. The devices of claims 1,2 wherein the VS is $Ge_{1-y}Sn_y$ and the active region is a strain balanced type-I stack of compressive $Ge_{1-2y}Sn_{2y}$ quantum wells with tensile Ge barriers.

4. The devices of claims 1,2,3 wherein the composition y ranges from 0.02 to 0.15 for device operation at wavelengths ranging from 1.55 to 5.00 μm.

5. The photodetector devices of claims 1,3,4 in which the substrate is doped N or P type and the cap layer contact is an Schotty barrier metal.

6. The photodetector devices of claims 1,3,4 in which the substrate is undoped and an interleaved pair of metal electrodes is employed upon the cap layer.

7. The devices of claims 1,2 wherein the VS is $Ge_{1-y}Sn_y$ and the active reqion is an unsymmetrically strained type-II heterostructure with holes confined in a tensile Ge layer and electrons confined in the relaxed buffer layer.

8. The devices of claims 1,2 wherein the VS is $Ge_{1-y-z}Sn_ySi_z$ and the active region is an unsymmetrically strained type-I heterostructure with electrons-and-holes confined in a tensile Ge layer.

9. The devices of claim 8 wherein y and z are approximately 0.2.

10. A unipolar intersubband long-wave-infrared photodetector-diode, or laser diode, or light emitting diode, or amplifier, or electrooptic modulator diode comprising:

    (a) a silicon substrate

    (b) a strain-relaxed $Ge_{1-y}Sn_y$ buffer layer upon Si, known as a virtual substrate, VS

    (c) an active direct-bandgap region made up of a strain-balanced type-I multi-quantum-well stack which has compressive $Ge_{1-2y}Sn_{2y}$ wells and tensile Ge barriers,

    (d) a strain-relieved capping layer of $Ge_{1-y}Sn_y$ that matches the VS composition,

    (e) metallic electrical contacts to the Si substrate and/or capping layer.

11. The photodetector devices of claim 10 wherein the VS and cap and quantum wells are doped N type

12. The photodector devices of claim 10 wherein the VS and cap and quantum wells   are doped P type

13. The laser, emitter, amplifier and modulator devices of claim 10 wherein the VS and cap are both doped N-type or both doped P-type for electron injecton or for hole injection, respectively.

14. The laser, emitter, amplifier and modulator devices of claim 10 wherein the resonant tunneling of injected carriers is used between adjacent periods of the active region in the manner of a quantum cascade.